

## Original Articles.

### REVERDIN AND OTHER METHODS OF SKIN-GRAFTING.

#### PART I. HISTORICAL.\*

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THE ancients well understood the art of bridging over skin defects by the use of the plastic flap. The earliest mention of the procedure, employed in rhinoplasty, is found in the Ebert papyrus, dating about 1500 B.C. Galen and Celsus wrote upon plastic surgery, as did also Antyllus and Paul of Aegina.

It was among the natives of India, however, that the operation reached its highest development in ancient times. From the Ayurveda (c. 100 B.C.) we learn that plastic flaps were turned on to the nose from the cheek, and later from the forehead. Some attempts also at plastic work about the ears were made. The operation was probably quite commonly performed, for ears and noses were amputated in those days as a punishment for crime. There seems to have existed among the Brahmins a certain caste, the Koomas, or potters, which considered the repair of mutilated features its especial province. Besides using the pediculated flap, from the cheek or forehead, they would sometimes vary the procedure, as Susruta tells, by slapping the skin of the buttock with a wooden shoe until it was quite congested, and then, with a leaf cut to proper shape as a pattern, cutting out a piece of skin with its subcutaneous fat, transplanting it and sewing it into place, uniting it to the freshened edges of the defect.

In the Middle Ages, as the necessity again arose, rhinoplasty came once again to be commonly employed. Some say it sprang into use independently of the work of the Hindoos; others, that it was brought to Italy by the Arabs. At any rate, in the fifteenth century the family Branca in Sicily rose to fame for its skill in plastic procedures, to be succeeded by the family Bojani, in Italy. The first systematic treatise on the subject dates from 1597, when Gaspar Tagliacozzi, of Bologna, who had won success in the treatment of the ear, lip and nose, expounded the method which was then in general use.

Whereas the Indian method provided that the pediculated flap be taken from close at hand, so that it need only be rotated on its pedicle to cover the defect, the Italian or Tagliacotian allowed for the taking of the flap from any portion of the surface of the body, provided only that it could be brought and fixed in close enough approximation to the area to be covered. For this sort of rhinoplasty the left upper arm was usually chosen, and on its anterior aspect two parallel cuts eight inches long were made down to the fascia, four inches apart. The strip thus formed was separated up from the fascia by blunt dissection, and under it was carried a sheet of oiled paper, to prevent formation of adhesions. After

a week or more, when the under surface had granulated in thoroughly, the upper end of the strip was cut across, the arm brought up to the face and fixed by straps, and the flap sewed into place.

Tagliacozzi had a few followers who reported successful cases, but rhinoplasty gradually sank into disuse and in course of time began to be considered impossible or fabulous, and his success was declared apocryphal. Reneaulme de la Garanne (1712) tried to rehabilitate it, proposing to simplify the operation by sewing into the defect a fresh flap immediately after cutting, without waiting for it to granulate. But the "investigators" of the eighteenth century were satisfied with writing Latin dissertations on the improbability of the operation's ever having been performed. Finally, at the end of the eighteenth century, the Paris Academy of Surgery expressed the accepted opinion when it declared that the operation was impossible.

#### REVERDIN GRAFT.

In the latter half of 1869 M. J.-L. Reverdin, a young Genevan (interne in the Hôpital Necker in Paris under Guyon), noticed, as Billroth had done, the occurrence of islands of epithelium in the midst of the granulations of ulcers. Accepting Billroth's explanation for the occurrence of these islands from proliferation of the epithelium of deep-lying portions of skin glands, or of scattered bits of the basal layer of epithelium, by chance uninjured by the destructive force, he recognized the importance of *aiding* epidermatization of ulcers by the *artificial implantation* of new islands to serve as centers of growth. Accordingly, in a patient who had lost the skin of his thumb, he tried the experiment of planting on the granulations two small bits (of about 1 sq. mm.) of epidermis lifted from the skin of the upper arm by the point of a lancet, without drawing blood, and held in place by a strip of diachylon plaster. These took root, and from them, and from other grafts applied later, the epithelium spread to the margin of the ulcer. He called this "epidermic grafting," and on Dec. 8, 1869, he presented a paper on the case to the Société Impériale de Chirurgie.

Reverdin had demonstrated that detached particles of living epidermis not only retained their vitality for a certain time, but that when laid upon a granulating surface, they were capable of entering into permanent union with it, and of *actively proliferating* toward the formation of new epithelium.

That detached portions of epidermis retained their vitality and would adhere again and become an integral part of the skin, Tigrî, of Sienna, had shown by the growth of the skin covering blisters, in 1867. Moreover, Frank Hamilton, of New York, had practiced, as early as 1854, the covering of ulcers of considerable size by marginal growth from a small pediculated flap.

Reverdin had independently arrived at a simple and dependable method of hastening the healing

\* Bibliography will appear only in reprints.

of fresh surface lesions and of completing the cicatrization of long-standing ulcers.

Reverdin's paper was discussed at the next meeting (Dec. 15, 1869), but he found only two supporters, MM. Guyon and Marc Sée. No one in France seemed to realize the possibilities of the procedure, although Sée reported one success, with Reverdin's aid, and Guérin another. The seed had not fallen upon barren ground, however, for Mr. Pollock, of St. George's Hospital, London, learning of the work of Reverdin in May, 1870, immediately put it into practice on a patient of eight years, suffering from an extensive ulcer of long standing after burns. His striking success at once aroused the enthusiasm of medical London, and within three months the procedure had been tried successfully by Holmes and Lee at St. George's (six cases); Mason, at Westminster (eight cases); Heath, at University College Hospital (two cases); Lawson and Arnott, at Middlesex (five cases); Bellamy, at Charing Cross, and Durham, at Guy's (four cases). Soon, also, Colles reported from Ireland, and Gillespie and Macleod from Scotland.

From England the method almost immediately spread to America, where it was taken up by Frank Hamilton, of New York; Chisholm, of Baltimore; and Porter and Coolidge, of Boston. In December, 1870, a series of five cases were reported from the Boston City Hospital by Belt, Handy and Bolles. Hodgen, of St. Louis, reported three successful cases a few months later.

From England again it spread to Germany. Czerny, working in Billroth's clinic, reported two successes, and expressed wonder that the German publications were silent on a matter with which the English periodicals were teeming. Almost at once enthusiastic reports followed from Hofmök, Heiberg and Schulz and Necolitzki, and in Thiersch's clinic histological investigations were begun by Kunitz and Thierfelder. Among the Russians it was taken up by Jacenko and Lindenbaum; in Italy, by Marcani, Perassi, Albanèse, Frederici and Amabile.

By this time France had become to some degree enthusiastic also, and one man, Fort, went to London to see Pollock operate. Finally, in 1872, Reverdin, having completed his histological studies under Ranvier in Claude Bernard's laboratory, wrote what is still the definitive article on epidermic grafts, based on a personal experience of about fifty cases, and on the wider experience of men abroad. From the English he learned that there was a well-defined limit to the proliferative power of the individual graft (Dobson); that, accordingly, multiple grafts were advantageous (Dobson) and would give a firmer and more rapidly forming cicatrix (Steele); that small grafts were better than large (Pollock); that grafting stimulated proliferation from the edges of the ulcer (Steele, Cowper, Dobson, Barlow) and that successive grafts gave successive stimuli (Steele); that grafting on a bleeding surface was usually unsuccessful (Mason), but that with hemostasis grafts took well on fresh surfaces, as after the amputation of a breast (Heath);

that grafts might be transplanted successfully on syphilitic ulcers (Clark); that grafts might be taken from another person (Dobson), either white or colored (Pollock, Bryant), or from amputated limbs (Forster, Smith); and that the papillary layer was the essential element (Steele, Page).

His cousin, August Reverdin, had stated the law that epithelium will grow most rapidly in the direction in which it will have the least distance to cover before reaching other growing epithelium, and four years later he was to invent a special concave lancet for taking grafts. Ollier had used a Beer cataract knife; Rouge, a seton needle; Pollock had used forceps and scissors; Heiberg and Schulz, cilia forceps; and Macleod had adapted a French instrument combining forceps and scissors (now called after Bryant, who first used it at Guy's, or after Smith, of Bartholomew's). It was not until 1874 that Agnew, of Philadelphia, originated the method of needle and knife. Pollock had originated, and had given up, the method of planting the grafts into incisions made in the granulations; Hamilton had tried this as well as erasing the granulations where the graft was to lie, and stitching the graft to the granulations, but had given up these procedures also. Czerny had grafted mucous membrane; August Reverdin, the wall of a dermoid cyst; Howard, of New York, bits of muscle cut from the patient's biceps; and Ollier, periosteum, on granulations, with reported success. The importance of immobilization of the part had been established (Ollier, Hamilton); Durham, dissecting up strips of the skin growing from the margins of the defect, had swung them in on to the granulations, leaving one end attached; Thiersch, two years later (1874), was to cut pinpoint grafts from this same pellicle and plant it on the ulcer.

#### THIERSCH GRAFT.

As experience with the new method broadened it became evident that there were drawbacks which had not been conceived of in the first enthusiastic reception of the procedure. Page, Gillespie's interne in Edinburgh, asserted in 1870 and 1871 that Reverdin grafts simply hastened natural cicatrization. Lindenbaum and Anderson (1871) severally found that the new scar caused contractures about joints like an ordinary cicatrix.

Ollier, of Lyons (with his interne Poncet), recognizing these disadvantages, was the first to attempt to overcome them (1871, 1872). His intention was not to create multiple centers of epidermatization by the dissemination of small bits of epidermis over the surface of a wound, but to substitute for the thin, stiff pellicle covering an ordinary cicatrix a membrane having the essential elements of normal skin, and preserving its characters. He accomplished this purpose by laying on the wound strips of epidermis pared or sawed off with the flat of a sharp knife, thick enough in the center to contain a portion of the dermis. He found that such grafts laid on close together so as to cover the entire wound surface at once completed the healing of the whole ulcer more rapidly, so that there was less cicatricial

tissue formation, and, therefore, less scar contraction; that the resulting skin was softer and more supple, contained in some degree hair follicles and sweat glands, and was more resistant to destruction from pressure or friction. He called this the method of "dermo-epidermic grafting," and he used it with good results where contraction was to be feared. Ollier was ignored by his countrymen, just as Reverdin had been.

Thiersch, of Leipzig, who had completed, in 1867, an important work on the healing of granulating surfaces, took up the matter of Reverdin grafts, and in 1874 expressed the dictum that the pinpoint grafts were good for hurrying cicatrization and for completing a process at a standstill, but that they were open to criticism inasmuch as the healing was slow, the new tissue was cicatricial and would contract, and might even fall off or melt away when apparently well healed, and that the resulting scar was cosmetically unsightly. He proposed as a relief of the contraction to remove with a razor all the granulation tissue, and to plant the grafts directly upon the firm substratum of fully formed and already contracted connective tissue. It was not until 1886 that he was able to report that he had perfected the operation of skin grafting by the use of films of epidermis, with a portion of the dermis, shaved off in strips and laid on so as to cover the wound entirely, the granulations (which should be six weeks old) having first been removed.

This report, read at the XV. Kongress der deutschen Gesellschaft für Chirurgie, attained wide publicity, and the procedure was immediately accepted, under the name of Thiersch-grafting, practically without modification and without recognition of Ollier's priority. Series of cases were reported from all sides. Surgeons in all lands adopted it as a routine and the more modest pretensions of the Reverdin graft were forgotten.

#### WOLFE GRAFT.

In the course of time the drawbacks of this method, too, became evident. It was found that Thiersch grafts covered scar tissue, which contracted in healing (Murray, McBurney, 1893; Lang, 1895; Steinthal, 1904; Kennedy, 1905), and that the new skin, if exposed to gross mechanical insult, such as continuous or overstrong pressure, or demands upon its elasticity, as about joints, would ulcerate through or slough (Henle and Wagner, 1899). Its use was especially discouraging in leg ulcers (Nagel, Jungengel, 1888). In short, the Thiersch method was uncertain and not always successful (Mayo-Robson).

In searching about for a means of furnishing a scar which would remain elastic, and would resist pressure, investigators happened upon the so-called second Indian method of rhinoplasty without a pedicle. This had been brought back from India at the beginning of the nineteenth century. Von Græfe had tried it (1818), and Dzondi, but failed. Bunker had a successful case in 1817. Dieffenbach tried exchanging two grafts on the arm of an anesthetic woman (1824); one graft

fell off and the other was accidentally pulled away. Dutrochet had a success, in 1836. These transplantations followed the old Indian method of including subcutaneous fat with skin.

Lawson, in London, made use, in 1871, of a single large thick Reverdin graft—that is, a *fat-free* flap of skin—in a case of ectropion, which healed with a resistant and non-contracting scar. News of this was brought from London to Germany that same year independently by Jacenko and Lindenbaum. Eye surgeons became interested in the procedure, and Le Fort and Wecker (1872), in France, both reported successes by this method in cases of ectropion, as did also Sichel (1875). It was Wolfe, of Glasgow, who, by his writings in 1875 and later, established the procedure firmly in ophthalmic practice. After him Zehender (1877); Berger, Robson and Snell, and Wicherl (1880); Williams, of Boston (1884); and Le Dentu (1888) reported successes.

Von Esmarch became aware of the advantages, cosmetic and other, of this over former methods, recommended highly its application to all plastic purposes about the face, and reported a considerable series of cases (1885, through his pupil Hahn; in 1888, and in an English article in 1889). His results were borne out by Ceci, of Genoa (1892).

For general purposes, use of the free flap had already been made desultorily by Ollier (1871) in separating syndactyly, and Gussenbauer (1875) to cover a heel. To Krause, of Altona, is due the credit for the application of the procedure to general surgery. At the XXII. Kongress der deutschen Gesellschaft für Chirurgie, in 1893, he advised the use of the Wolfe graft for all purposes where the Thiersch had been found lacking, and reported twenty-one cases in which whole-thickness grafts without fat had been applied to defects of considerable size, and covering a wide range of conditions.

At the afternoon session of the same day, Hirschberg claimed priority for the free flap according to the Indian method,—including fat, and taken during hyperemia,—and reported four cases. But Krause had used this method and denied that there was any advantage in the presence of fat or in the condition of hyperemia, and the method advocated by Hirschberg has fallen into disuse.

Krause's paper was well received in Germany and abroad, and his example was widely followed. The clinical researches of Henle and Wagner (1899), of Reuter (1899), of Widman (1902), and of Braun (1903) established the elasticity, the movability, the essentially normal appearance and functioning of the new skin, and its durability even in the most exposed places. The histological investigations of Enderlen (1897), Braun (1899) and Unna bore out the clinical findings.

#### FLAP GRAFT.

Of the Wolfe graft, Krause himself had stated that without complete asepsis and hemostasis failure commonly occurred; with the best of conditions success was to be expected in something less than the percentage given by the Thiersch

graft. These facts, and the necessary restriction of its use on account of the limitation in size of the area which can be grafted, has led recently to the rather extended application in general surgery of the pediculated or flap graft of the plastic surgeons.

Soon after rhinoplasty had been discounted by the French, it was brought to England by Lucas, an English surgeon, who had performed it successfully in India, after the native methods. Lynn (1803) and Sutcliffe tried it, both unsuccessfully. Then Carpué, in 1814, reported two successful cases.

Von Græfe, in Germany, became interested in the subject and translated Carpué's book (1817). He preferred, however, the Italian method over the Indian method which Carpué had employed. He modified the procedure of Tagliacozzi by sewing into place the fresh flap, just after cutting, without waiting for it to granulate, thus making of it a single operation, adopting unconsciously the recommendation of Garanne (1721). He reported one success, and his technic came to be called the German method.

Von Græfe had many followers, and from him descended the whole line of plastic surgeons: in Germany, Dieffenbach, Chelius, Rust, von Walther, Langenbeck, Thiersch; in France, Delpech, Dupuytren, Lisfranc, Velpeau, Labat.

Dieffenbach, who extended the province of plastic surgery to include the ear, eye, lips, perineum and urethra, came to prefer the older granulating flap, and strongly advised against the use of the fresh flap of Von Græfe (1845); as a result of his influence this in its turn was dropped for the time being in Germany.

In general surgery the use of the flap graft, Indian and Italian, comprising skin and subcutaneous fat, applied fresh or granulating, developed gradually from this time on for replacing scar tissue in contractures, and in the treatment of deep wounds of the hand, wounds about joints and in localities exposed to pressure or friction, as the heel.

South, in his edition of Chelius' "Surgery," says, in 1847, that the use of the pediculated flap for these purposes was so common in England that cases were not reported. In the rather scanty early literature on the subject are cases by Fabrizi (1843); Hamilton, of New York (1854); Cabot, of Boston (1862); Berend (1863, 1882); Wood, in England (1864); Ollier and Delore (1872); Truehart, of Texas (1875); Gussenbauer for Billroth (1875); Czerny, Berger (1878); Adams (1881); Socin (1883); Lannelongue and Kappeler (1885). Many textbooks gave brief mention to this application of plastic surgery.

The widespread appreciation of the importance of these methods to the general surgeon — the real renaissance of the flap graft — is due to the work of Maas, in 1884, 1885 and 1886, with the fresh flap. His exposition of the indications, application and technic of the fresh flap, Indian or Italian, was so clear and able that he won immediate attention. He was followed by Nicoladoni, Gerster, of New York (1886), Salzer and

Israel (1887). On his death, Wagner (1887) took up the subject prominently, and successes by a similar technic were reported by von Hacker (1887, 1888, 1894); Jungst, for Czerny (1887); Keetly (1887, 1902, 1905); Kirmisson, Czerny, Berger (1888); Silbernig, in Russia (1889), and so on.

There have been few modifications of the original methods.

"Wanderlappen," flaps carried to inaccessible places by attaching them first to a slit in the skin somewhere between the original source and their final resting place, have been used successfully by Israel and Hahn (1887), von Hacker (1888, 1904), Steinthal (1904), and Hagen (1905). Keetly (1887, 1902) exchanged flaps between face and arm in treating a mole in an infant. Von Hacker (1888) and Croft (1889) rehabilitated the original Tagliacotian method under the name of "bridge graft." The confinement of a finger, hand or limb in a pocket of skin on the abdomen, thigh or back was practiced by Ollier (1872), North (1886), von Hacker (1886), and Schroeder, after Fenger (1900). Gersuny (1887) turned a flap from the neck into the mouth on a pedicle of subcutaneous tissue. Greenough, of Boston (1903), practiced immediate skin sliding to close the wound left by the flap, and Stone, of Boston (1905), after Greenough's suggestion, dissected out at a secondary operation a pad of fat left under a flap on the palm. Otherwise the teachings of Maas and Wagner are still followed.

#### OTHER METHODS.

In addition to these four types of skin grafting, the Reverdin, Thiersch, Wolfe and the flap graft, there have from time to time been applied various irregular methods, which, though none have ever come into general favor, merit mention here if for no other than historical reasons.

"Scrapings," "epithelial sowing," "skin dust." — Marc Sée, of Paris, in 1870, reported a favorable result from scattering over an ulcer epidermic scales obtained by scraping the skin with a sharp knife, held vertically, without drawing blood. Fiddes, in the *Lancet* (1870), reported successful results, and he was confirmed by Ash (1870) and Poland (1871) in England; Stein, of New York, and Hodgen, of St. Louis (1871). Coolidge, of Boston (1870), tried scraping of the deeper layers after removing the epidermis by a blister, with partial success. Following the example of Fiddes the method was tried by Goldie, Jacenko, Czerny, Hicks (in 1871); Reverdin, Bryant (1872); Woodman (1873); Agnew, of Philadelphia (1874), and all reported *no* success. Macleod (1871) was unsuccessful, but noticed a stimulation of growth in the margins of the ulcer. Von Mangoldt (1895, 1902) rehabilitated the method, but advised rejection of the outer horny layer, and a scraping of the deeper layers down to the papillæ. The resulting mixture of blood and deep cells was deposited upon the ulcer. Successful results by Mangoldt's method were reported by Mann (1895), Hænel (1896), Kozerski (1897), and by his pupil Næsske (1906).

In America, Howard (1899) reported good results by the older method, without drawing blood, and Wiggins (1899) successfully modified the technic by removing the outer layers of the sole of the foot, macerating the deeper layer for twenty-four hours, scraping, triturating till dry and then applying.

*Warts, corns, callosities.*—Hodgen, in 1871 used shavings of corns. Leale, of New York (1878), got good results by removing warts entire and then separating them into rod-like portions and planting these. Kibbler (1894) reported excellent results with thin slices of calloused or indurated epithelial tissue from the palms or soles.

*Blister skin.*—Tigri, of Sienna (1867), showed that the skin of a blister, entirely separated, would heal into place. This principle was first adapted to skin grafting by Freeman, of Denver (1895, 1896), who planted large pieces of membrane of blisters, occurring after burns, or raised with cantharides. Lusk, of New York (1895, 1896), independently described the same method, and reported good results. He used smaller pieces of the blister skin. He found that after drying and sterilizing between glass plates, this material would keep for some days. He also used dried blister tops, which he softened in boric solution and cut up into bits. Overton, of New York (1896), used the method, but found that it was slower and less sure than the Reverdin. Wentscher tried it in Germany (1898) with no result. Oliver, who had worked with Freeman, tried it (1899) with but little success. Blondel (1905) reported from France a successful case of implantation of blister skin into an artificial vagina.

*Blister fluid.*—Macleod (1871) reported good results from the use of blister serum. He put up a wall of wax about the ulcer and poured in the fluid. After him, Jacenko (1871) tried it with no success, and stated that it acted only as a dressing.

*Exfoliated epithelium.*—Hodgen (1871) reported some success with the planting of epithelium which had exfoliated from patients lying in bed. Agnew (1874) reported no success with the same method. Lusk (1896) used sheets of exfoliated epithelium, which he had softened and sterilized, with success.

*Hair roots.*—Hairs, with their roots, had been transplanted successfully early in the nineteenth century by Dzondi and Dieffenbach. Scheininger (1875) regarded hairs accidentally dropped on a granulating surface, with their roots and some peri-bulbar elements remaining attached, as a probable source of origin of some of the islands of epidermis which are seen in ulcers. Hodgen (1871) tried sprinkling hair roots over ulcers, but did not report on the success of the experiment. Wentscher (1898) reported no success with this method.

*Finger nails* were experimented with by Hodgen.

#### HETEROPLASTY. (GRAFTING FROM ANOTHER PERSON.)

From the early days of the Reverdin graft, *amputated limbs* have been used as a source of

material. Foster and Smith (1871) seem to have applied this method first. Bryant reported the same year, but made the reservation that many of the grafts so taken failed to grow. Ollier (1872) noted that grafts cut from amputated limbs might be preserved at zero temperature. Martin (1873), after extensive studies with animals and man, found that human grafts would preserve their power of proliferation twenty-four hours, or longer, if kept cold, but only six or seven hours if kept at 82° F. Agnew used amputated limbs in 1874. Fisher reported on their successful use as a source of grafts, after the method of Ollier, in 1880. Mixter, in Boston, tried it the same year, with negative result. Brewer (1882), in a series of seven cases, found that grafts could be applied successfully up to thirty-six hours. Esmarch (1885), Franke (1887), Nagel (1888) and Lucas-Championnière (1888) followed the same technic with indifferent success, the two latter remarking independently that grafts from amputated limbs were likely to melt away and disappear six to eight weeks after they had healed in place. Symonds reported success in 1889; Timmerman, in 1899, with grafts taken from a limb six hours after amputation; Dupraz (1899) with grafts from a limb six hours after amputation; McGuire (1903) and Hartmann and Weirick (1903) with a four-hour-old leg.

The use of *cadavers* as a source of material was first advocated by Colrat (1871). Successes have been reported by Girdner (1881) with grafts taken six hours post-mortem, by Bertens and Werner (1888) twenty minutes post-mortem, and by Ivanovna (1890) with grafts taken two hours after death. Rathey (1886) reported no success with Thiersch grafts taken from fresh corpses.

The question of the length of time a graft would preserve its power of proliferating after being cut from a limb or cadaver has been the source of a serious experimental study by many men. The results of Ollier, Martin and Brewer have already been mentioned. Von Winiwarter (1892) observed that these experiments have no practical value. Wentscher (1894, 1903) got grafts to take, after having been preserved (wrapped in sterile gauze in normal salt solution) for twenty-two days, and advised that Thiersch grafts be cut one day and applied the next. Lusk (1895) reported success with dried blister skin preserved four hundred and eighteen days. Enderlen (1898) sought to test the results of Wentscher. He had two successful results from grafts preserved moist, no success with grafts preserved dry. Marchand (1897, 1901) experimented with the viability of grafts, as did also Giere (1900). Llungren (1899) reported success with grafts kept six months in sterile ascites fluid. Perrolini (1900) got successful "takes" with Krause grafts kept six days in normal salt solution; not so long when kept dry. The best temperature he found to be zero. Burkhardt (1905) set the limit of viability at twenty-four hours in the open air, and at eight days if preserved in a moist chamber. He also advised that the Thiersch operation be done in two stages.

The use of living persons other than the patient as the source of material for grafting originated probably with Reverdin. It was soon found that this procedure entailed a danger which could not be disregarded — the danger of transmission of disease. Völcher (1872) reported a fatal case of smallpox inoculated by grafts. Deubel (1881) reported the inoculation of syphilis from son to father in grafting. Czerny (1886) reported a case of transmission of tuberculosis. Other cases are cited by Becker (1881) and Mombert (1894).

Whether heterogenous grafts are taken from a living or from a dead subject, there is with them some likelihood of failure to form permanent skin. This was observed by Beresowski (1893), who came to believe that heterogenous grafts played a merely passive rôle in the healing of an ulcer; by Scholz (1898); by Næsske (1906), who got poor results as compared with autogenous grafts, even when the material was taken from relatives.

Bryant (1872) has made the statement that heterogenous grafts are dangerous and often fail. Since his day many men have repeated the advice that grafts should always, if possible, be taken from the patient himself, — Franke (1887), Lucas-Championnière (1888), Nagle (1888), Sick (1892), Henle and Wagner (1899), Widmann (1902), Bivings (1902), Mellish (1904), Weischer (1906), Bull (1906).

On the other side, Lauenstein (1904) has stated that the reported relative ill success with grafts taken from other persons is probably to be explained by carelessness in technic.

#### ANIMAL GRAFTS.

Animal skins have been used for therapeutic purposes since early antiquity. Baron Larrey commends the use of the hide taken from a living animal as a dressing or covering, and cites its effective application in the case of the grievously wounded Marshal Lannes. According to the *Lancet* of that year, a child was wrapped in the fresh bleeding hide of a sheep as late as 1871 by an English practitioner, though this was to combat shock. Small pieces of fresh kitten or puppy skin have been used popularly for ages to encourage the healing of intractable ulcers. The idea survives in this community in the use of eel skin and slices of beefsteak, salt-pork, and in the employment of animal extracts, fluid or powdered, extolled by manufacturers as dressings for ulcers.

Experimental transplantation from and among animals was performed early in the history of medicine. Thus we hear that Demetrius and Darcusius transplanted feathers of fowl. In the eighteenth century there were many investigators along this same line, for John Hunter, who transplanted spurs, teeth and testes among fowl, speaks of his experiments as "common and well known." Teeth were transplanted by Paré, Fanchard (1728), Bourdet (1757), Hunter (1780), and Astley Cooper. Claws and spurs were transplanted by Duhamel (1746) as well as Hunter, and their results were verified by Philipeaux (1853, 1870).

What were probably the first experiments on the transplantation of skin among animals were performed by Baronio, of Milan (1804). His work was suggested, as he says, by watching an itinerant vender of medicines shave a piece of skin from his own arm, lay it back on to the wounded surface, dress it with his much-vaunted salve, and exhibit his arm with the skin healed in place a week later. Baronio's successful transplantations in sheep were imitated on other animals with varying success by Wieseman (1823), Dieffenbach (1829), Lentilhac (1848), Bitot (1857), Azam (1860), Paul Bert (1863) and Mantegazza (1866). Bert was the first to definitely suggest the practicability of employing animal skin to replace surface losses in man.

With the popularization of the Reverdin graft, eight years later, Bert's suggestion was eagerly taken up; Reverdin, Hofmokl, Phillipe, Necolitzki, Dubreuil and Houzé de l'Aulnoit, in 1871 and 1872, reported successes with transferences of the skin from the dog, rabbit and cow to man. Czerny and Jacenko (1871), Folet (1872) and Aug. Reverdin (1876) had no success. Raven (1877) used a pig, and Raymond (1877) a kid. After Thiersch published his method, grafting from animals to man took a fresh impetus, and from 1886 to the present day many men have used animals as a source of grafts. Hubscher (1888), McGuire and Flegenheimer (1903) have had success with pig skin; Miles (1889), Van Meter (1890) and Sneve (1905), with puppies; Redard (1888) and Bianchi and Fiorani (1900), with skin from the inner side of the wing of chickens, and Aldrick with pigeons; and Allen (1884), Peterson (1885, 1887), Dubousquet-Laborderie (1886, 1887), Baratoux (1887), Nesterovsky (1888), Fowler (1889), Watson Cheyne (1890), and Ranking (1906), with frog skin.

The claim has been made that skin from animals — warm-blooded animals rather than cold-blooded, young animals rather than middle aged or old — forms permanent union with human tissues, loses its pigment and most of its hairy growth, and soon develops all the characteristics of human skin. But failures have been too frequent to make this procedure practicable and reliable for the surgeon, and not a few men who have reported primary successes have announced later that the grafts loosen after an interval and fall off or are absorbed and disappear. Among the critics are Rathey (1886), Franke (1887), Redard, Cadogan-Masterman (1888), Sick (1892), Henle and Wagner (1899), and, above all, Alexander Miles, of Edinburgh, who has been, perhaps, the most consistent employer of animal grafts and whose experience extends over some twenty years. Orcel (1888) states his belief that animal grafts act merely as a sort of protective dressing, and he is substantiated by the experiments of Beresowsky (1892).

#### EGG-MEMBRANE.

In the late seventies gold beater's skin was in rather common use as a dressing for skin grafts. In the early eighties fresh egg-membrane was

substituted as being more aseptic. Berthold and Haug (1889) experimented with egg-membrane as a material for transplantation. They used it with the outer side next the wound, and came to the conclusion that it did not proliferate but acted passively, encouraging growth of epithelium from the margins *by protection*.

Amat (1895) independently established the method of using the thin *internal* layer of the egg-membrane, cutting it away where the two layers are separated by the air chamber at the large end of the egg. He reported nine successes in seventy-four cases from planting tiny squares (4 to 5 sq. mm.) upon granulating surfaces. Schüller (1899), without reference to Amat, reported two successful cases by the use of the *whole thickness* of the membrane, laid inner side down, in larger pieces. His studies disclosed on the inner side of the pellicle a delicate layer of epithelial cells, only loosely adherent to the network of fibrillæ constituting the mass of the membrane. Under conditions of strict asepsis, if handled carefully, this layer would adhere to the granulations and proliferate to form epidermis. He recommended the procedure for tuberculous patients and others too weak to stand more severe handling. Amat (1900), to establish his priority, republished his article, and wrote a new one, giving Schüller credit for his histological investigations, affirming that about one case in eight is a success, and advising the procedure in women, children and cowards who could not stand an operation or who would not allow the Reverdin or Thiersch method to be practiced. J. C. and O. Platon (1900) investigated the subject. They used, after Schüller, the whole thickness, and covered in the wound surface entirely with large pieces. Healthy skin developed in eight days. They concluded that it exercised a merely protective function. Amat wrote again (1905) to popularize the method, and reported two successful cases.

Gaston (1896) was probably the first to use the method in this country. He found it satisfactory. Overton (1898) used it with partial success. Olliver (1899) had no success. Kessler (1900) found it satisfactory, but slower than Thiersch grafts. Fowler (1900) also tried it.

#### SPONGE GRAFTING.

In 1881 Hamilton, of Aberdeen, originated the method of "sponge grafting," and reported five cases. He used thin slices of animal sponge which had been thoroughly carbolyzed, laying them so as to cover in the granulating surface. His idea was to furnish a framework of absorbable material through which the granulations could build, which would support them until they were covered in with epidermis. The method was tried extensively in Germany, and less widely in this country, but was found to possess few merits. It has been used in the orbit after enucleation. Following this suggestion, ophthalmic surgeons have experimented with many substances (animal eyeballs, and balls of catgut and bone included) down to the present-day employment of the globe of glass.

## REVERDIN AND OTHER METHODS OF SKIN-GRAFTING.

### PART II. TECHNIC AND CASES.

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#### REVERDIN GRAFTING.

THE method of epidermic transplantation, originated by Reverdin, is the simplest and most widely applicable mode of covering in a raw or granulating surface which we have at our disposal. Like many another procedure of demonstrated value, it has fallen gradually into disuse, so that, with a few exceptions, textbooks and manuals mention it disparagingly, or not at all.

More brilliant and complicated methods for accomplishing a similar purpose have arisen and have occupied the center of the stage until their deficiencies became evident and until they, in turn, were supplanted in general favor. Now, when ingenuity seems at last to have exhausted itself, it is worth while to consider the peculiar advantages of the original and now practically discarded method.

In the first place, *it is essentially a minor operative procedure*. Although in planting grafts over extensive surfaces, where one is desirous of covering in the whole area at one sitting, it may be advantageous to employ a general anesthetic, cocaine ordinarily suffices, and, indeed, in many cases one can get along without any anesthetic, either local or general. The older operators used no anesthetic, or an ether spray (Wood, 1871), or a freezing mixture (Ollier, 1872). A hypodermic barrel of Schleich's solution (.2% cocaine), used to raise successive wheals, should allow for grafts enough to cover sixteen square inches; infiltration of the cutis does not interfere with the viability of the grafts. For this reason, therefore, the "pinpoint" method may be used in persons wasted by old age or exhausting illness, as well as in cases where general anesthesia is contra-indicated for constitutional reasons. Moreover, in the extensive burns, where early covering in of raw and suppurating surfaces is so much to be desired, grafting by the Reverdin method may be started considerably sooner than would be deemed proper with any of the other methods. Immediate decrease in suppuration occurs after grafts are placed. If the area be extensive, at each dressing new application of grafts can be made under cocaine until the entire surface is covered.

*The procedure is simple and may be performed by one person upon a patient in his bed at home.* It requires only a sharp scalpel, and two or more new bayonet or cambric needles. These had best be sterilized in alcohol. The point of a needle is thrust through the epidermis, which is then elevated, and a small morsel shaved off with the knife. This is transferred at once on the needle point to the granulating surface, where it is im-